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Improved outcomes in survivors of cardiac arrest qualified for early coronary angiography: A single tertiary center study

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ABSTRACT

Introduction: Most cardiac arrests in adults are related to coronary artery disease (CAD), and the role of early invasive cardiology procedures remains unclear.

Aims: We investigated the prognosis for patients hospitalized for out-of-hospital cardiac arrest (OHCA) or in-hospital cardiac arrest (IHCA) who were referred within 24 hours to a tertiary cardiology department, with a focus on the role of early coronary angiography (CA) and percutaneous coronary intervention (PCI).

Methods: This was an observational, single-center study using retrospective and prospective cohorts. Consecutive patients hospitalized for OHCA or IHCA and referred within 24 hours to a cardiology department were included in the study. Survival until hospital discharge was the primary outcome.

Results: One hundred and forty-eight patients aged 71 (14) years were included, 68 hospitalized for OHCA, and 80 patients after IHCA. Overall, in-hospital survival in the study group was 45% (66/148). In a multivariable logistic regression model, independent predictors of death were ejection fraction (EF) ≤30% (odds ratio [OR], 4.1; 95% confidence interval [CI], 1.69–10.03), blood oxygen saturation (SpO_2) ≤90% (OR, 2.77; 95% CI, 1.19–6.46), non-ST-segement elevation myocardial infarction (NSTEMI) (OR, 2.71; 95% CI, 1.02–7.21). The risk of death was lower in patients who underwent early CA (OR, 0.28; 95% CI, 0.1–0.74) or received at least one defibrillation (OR, 0.11; 95% CI, 0.05–0.27), even after adjustment for other factors.

Conclusions: In this series from a tertiary cardiac center, patients who underwent early CA had improved outcomes after cardiac arrest. In the multivariable logistic regression model, lower SpO_2, lower EF, and NSTEMI were independent risk factors of death, whereas early CA and initial shockable rhythm improved survival.

Key words: out-of-hospital cardiac arrest, percutaneous coronary intervention, sudden cardiac death

INTRODUCTION

Sudden cardiac death is a major public health issue, even though over the last years, cardiac arrest management has changed in all stages of the "chain of survival", starting from the implementation of public education programs, such as early call-out of emergency services and basic cardiopulmonary resuscitation (CPR), to the evolution of automatic external defibrillators (AED) and use of in-hospital therapeutic hypothermia [1].

However, outcomes after out-of-hospital cardiac arrest (OHCA) are unfavorable due to frequent irreversible cerebral and cardiac injury. Approximately 70% of these patients suffer from significant stenosis or acute occlusion of the coronary artery, and a significant target of treatment is, therefore, to achieve adequate reperfusion quickly and consequently to stabilize rhythm and hemodynamics [2, 5].

According to the recent European Resuscitation Council Guidelines for Resuscitation, emergency cardiac catheterization (and percutaneous coronary intervention [PCI] if required) is recommended in adult patients with the return of spontaneous circulation (ROSC) after OHCA of a suspected cardiac origin with ST-segment elevation (STE) on

WHAT'S NEW?

In this analysis from a tertiary cardiology department, subjects suffering from a cardiac arrest, who qualified for early coronary angiography had improved outcomes in terms of survival and neurological status. In the multivariable logistic regression model, we identified lower blood oxygen saturation, lower left ventricular ejection fraction, and non-ST-segment elevation myocardial infarction as independent risk factors of death, while qualification to early coronary angiography, as well as initial shockable rhythms, improved survival.

the electrocardiogram (ECG) [1]. Considering a consensus statement from the European Association for Percutaneous Cardiovascular Interventions/Stent for Life groups, cardiac catheterization should be performed immediately in the presence of STE and considered as soon as possible (within 2 hours) in other patients in the absence of an obvious non-coronary cause, particularly if they are hemodynamically unstable [3]. Among patients resuscitated from ventricular fibrillation/pulseless ventricular tachycardia (VF/pVT) OHCA with STE on their post-resuscitation ECG, the prevalence of coronary artery disease (CAD) varied between 70% to 85% (more than 90% of these patients underwent successful PCI). Conversely, among patients resuscitated from VF/pVT OHCA without STE on their post-resuscitation ECG, the prevalence of CAD was lower and varied between 25% to 50% [4].

As opposed to the scenario with obvious ST-segment elevation myocardial infarction (STEMI) signs, the impact of early routine qualification for invasive cardiology procedures on prognosis remains unclear. Therefore, in this single-center study, we investigated outcomes of patients hospitalized in a tertiary cardiology department within the first 24 hours after OHCA or after in-hospital cardiac arrest (IHCA), with a focus on the role of early coronary angiography (CA) and PCI.

METHODS

This was an observational single-center study using retrospective and prospective cohorts in the 2010–2017 period. The data regarding analyzed subjects were extracted through a medical record review and included consecutive patients who were hospitalized in the tertiary cardiology center within the first 24 hours after OHCA or IHCA (108 subjects were analyzed retrospectively and 40 — prospectively). The study was approved by the Local Institutional Review Board (no. RNN/189/15/KE). Patients provided written informed consent to participate in the study.

The decision to qualify a patient for CA was made by a physician on duty, and it was based on synthetic, individualized clinical assessment of the likelihood that cardiac arrest was due to an acute manifestation of CAD — according to the recent European Resuscitation Council Guidelines for Resuscitation.

PCI success was determined as Thrombolysis in Myocardial Infarction (TIMI) level 3 flow in the target vessel following coronary angioplasty [6], less than 50% residual stenosis, and resolution of STE (in STEMI patients) by at least 70% on an ECG recorded after 60–90 min after the procedure. Data concerning the cardiac arrest incident were investigated using Utstein-Style guidelines [7]. Survival till hospital discharge was the primary measured endpoint, and we aimed to identify prognostic factors related to survival.

Post-arrest neurologic status was evaluated at discharge with a cerebral performance category (CPC) measure [8].

Statistical analysis

Statistical analysis was performed using MedCalc version 12.0 (MedCalc Software, Ostend, Belgium) and STATISTICA version 13.1 (StatSoft, Kraków, Poland). We made a wide analysis of demographics and relevant clinical characteristics. Data were presented as percentages for categorical variables and as mean with standard deviation (SD) or median with interquartile range (IQR) for continuous variables depending on their distribution. The normality of data distribution was tested using the Shapiro-Wilk test. Student's t-test for independent variables or the Mann-Whitney U-test were applied to test intergroup differences. The categorical variable analysis was performed with the χ^2 test and Fisher's exact probability test. For continuous variables, the receiver operating curves analysis was performed to establish optimal cut-off values for endpoint prediction. Based on single-variable tests, the multivariable logistic regression model (including variables with *P*-value <0.2 in single variable analysis) was applied to identify independent predictors of death, and odds ratios (OR) with 95% confidence interval (CI) were presented. All *P*-values were 2-sided, and *P*-values of less than 0.05 were considered statistically significant.

RESULTS

Baseline clinical characteristics of the study group are presented in Table 1, and angiographic characteristics of studied patients are shown in Table 2.

Overall, 148 patients (61 females), mean (SD) age 71 (14) years (range 26–95) were included; 68 patients were hospitalized for OHCA and 80 patients were after IHCA, 46 were further transferred to the intensive care unit.

The proportion of patients discharged home in the study group was 45% (66/148) (54% after OHCA, 36% after IHCA). Early CA (<24 hours from admission) was performed in 99 (66.9%) patients (including immediate procedure

Table 1. Baseline characteristics of the study subjects

	Early CA group (n = 99)	No CA (n =49)	*P*-value
Age, years, mean (SD)	71 (12)	72 (17)	0.15
Male, n (%)	64 (65)	23 (47)	0.06
Survivors (%)	55 (56)	11 (22)	<0.001
Arrest witnessed, n (%)	87 (88)	42 (86)	0.91
VF/pVT, n (%)	56 (57)	16 (33)	0.01
PEA/asystole, n (%)	43 (43)	33 (67)	0.01
ROSC, n (%)	86 (87)	35 (71)	0.03
Transfer to ICU, n (%)	41 (41)	20 (41)	0.91
Defibrillation attempts, median (IQR)	1 (0–2)	0 (0–1)	0.005
Admission SBP, mm Hg, median (IQR)	109 (99–120)	95 (80–116)	0.02
Admission DBP, mm Hg, median (IQR)	68 (60–70)	60 (50–70)	0.15
Admission SpO_2%, median (IQR)	90 (90–93)	90 (85–92)	0.005
STEMI, n (%)	39 (39)	2 (4)	<0.001
NSTEMI, n (%)	37 (37)	6 (12)	0.003
UA, n (%)	11 (11)	1 (2)	0.11
PCI, n (%)	74 (75)	0 (0)	<0.001
Cerebral Performance Category at discharge, median (IQR)	3 (1–5)	5 (3–5)	0.003
OHCA/HCA, n (%)	45 (45)/54 (55)	23 (47)/26 (53)	0.99
Admission EF (%), median (IQR)	35 (25–44)	30 (20–49)	0.31
Admission hs-cTnT, ng/ml, median (IQR)	0.25 (0.10–1.48)	0.25 (0.05–0.25)	0.006
Admission CK-MB mass, ng/ml, median (IQR)	14.4 (4.7–60.5)	5.7 (2.8–15.1)	0.008
Admission NT-proBNP, pg/ml, median (IQR)	1862 (874–5651)	6446 (1792–8150)	0.03
Hypercholesterolemia, n (%)	82 (83)	28 (57)	0.25
Diabetes, n (%)	36 (36)	23 (47)	0.29
Hypertension, n (%)	85 (86)	39 (80)	0.99
Nicotine addiction, n (%)	27 (27)	2 (4)	0.002

Abbreviations: CA, coronary angiography; CK-MB mass, creatine kinase-MB isoenzyme; DBP, diastolic blood pressure; EF, ejection fraction; HCA, hospital cardiac arrest; hs-cTnT, high sensitivity cardiac troponin T; ICU, intensive care unit; IQR, interquartile range; NSTEMI, non-ST-segment elevation myocardial infarction; NT-proBNP, N-terminal pro-B-type natriuretic peptide: OHCA, out-of-hospital cardiac arrest; PCI, percutaneous coronary intervention; PEA, pulseless electrical activity; pVT, pulseless ventricular tachycardia; ROSC, return of spontaneous circulation; SBP, systolic blood pressure; SD, standard deviation; SpO_2, peripheral oxygen saturation; STEMI, ST-segment elevation myocardial infarction; UA, unstable angina; VF, ventricular fibrillation

Table 2. Characteristics of patients who underwent coronary angiography

	Survivors (n = 55)	Non-survivors (n = 44)	*P*-value
No lesion, n (%)	10 (18)	8 (18)	0.087
Single vessel disease, n (%)	18 (33)	7 (16)	
Two vessel disease, n (%)	12 (22)	7 (16)	
Three vessel disease, n (%)	15 (27)	22 (50)	
Target vessel revascularization (n = 74; 100%)			
LMCA, n (%)	2 (5)	8 (25)	0.05
LAD, n (%)	21 (50)	14 (44)	
LCx, n (%)	9 (21)	7 (22)	
RCA, n (%)	10 (24)	3 (9)	
PCI, n (%)	42 (76)	32 (73)	0.85
PCI successful, n (%)	36 (65)	26 (59)	0.84
STEMI, n (%)	24 (44)	15 (34)	0.33
NSTEMI, n (%)	17 (31)	20 (45)	
UA, n (%)	8 (15)	3 (7)	
No ACS, n (%)	6 (10)	6 (13)	
Defibrillation attempts, median (IQR)	1 (1–2)	0 (0–1)	<0.001
Admission SpO_2, %, median (IQR)	92 (90–94)	90% (88–92)	<0.001
Shockable rhythm, n (%)	43 (78)	13 (30)	<0.001
Admission SBP, mm Hg, median (IQR)	110 (100–120)	100 (85–120)	0.03
Admission DBP, mm Hg, median (IQR)	69 (60–70)	65 (50–70)	0.25
Admission EF (%), median (IQR)	40 (28–47)	30 (20–38)	0.002
Admission hs-cTnT, ng/ml, median (IQR)	0.41 (0.10–1.87)	0.25 (0.10–1.12)	0.94
Admission CK-MB mass, ng/ml, median (IQR)	13.4 (4.4–44.1)	19.4 (6.3–72.0)	0.23
Admission NT-proBNP, pg/ml, median (IQR)	1604 (551–5127)	2372 (1444–5929)	0.28

Abbreviations: ASC, acute coronary syndrom; LAD, left anterior descending artery; LCx, left circumflex artery; LMCA, left main coronary artery; RCA, right coronary artery; other — see Table 1

Table 3. OHCA vs. IHCA comparison

	OHCA (n = 68)	IHCA (n = 80)	*P*-value
Age, years, mean (SD)	69 (14)	73 (13)	0.03
Male, n (%)	46 (67)	41 (51)	0.04
Survivors (%)	37 (54)	29 (36)	0.03
VF/pVT, n (%)	49 (72)	23 (28)	<0.001
PEA/asystole, n (%)	19 (28)	57 (71)	<0.001
ROSC, n (%)	66 (97)	55 (69)	<0.001
Transfer to ICU, n (%)	38 (56)	23 (29)	0.02
Coronary angiography, n (%)	45 (66)	54 (67)	0.86
PCI, n (%)	24 (53)	38 (70)	0.05
Defibrillation attempts, median (IQR)	1 (1–3)	0 (0–1)	<0.001
SBP, mm Hg, median (IQR)	110 (95–120)	100 (90–118)	0.19
DBP, mm Hg, median (IQR)	63 (60–70)	60 (56–73)	0.95
SpO_2, %, median (IQR)	90 (89–93)	90 (88–93)	0.26
STEMI, n (%)	15 (22)	26 (32)	0.47
NSTEMI, n (%)	20 (29)	23 (29)	
UA, n (%)	7 (10)	5 (6)	
No ACS, n (%)	26 (38)	26 (32)	
EF, %, median (IQR)	32 (25–47)	30 (25–44)	0.92
hs-cTnT, ng/ml, median (IQR)	0.25 (0.08–0.81)	0.25 (0.10–0.60)	0.88
CK-MB mass, ng/ml, median (IQR)	12.6 (4.4–49.7)	9.5 (4.0–42.6)	0.71
NT-proBNP, pg/ml, median (IQR)	1716.5 (512.5–4783.0)	5372.0 (1867.5–8137.8)	0.002

Abbreviations: IHCA, in-hospital cardiac arrest; TIMI, Thrombolysis in Myocardial Infarction; other — see Table 1 and 2

when infarction was suspected), more frequently in survivors (83.3% vs. 53.7%; *P* <0.001), similarly to PCI (59% vs. 37%; *P* = 0.006). The survival rate was 55% in those who qualified for CA, 22% in those who were disqualified, and 55% in those with successful PCI. The PCI success rate was similar in survivors 85% (36/42) vs. 81% (26/32) in non-survivors (*P* = 0.84). Mean (SD) duration of hospitalization was 12.8 (4.7) days for survivors and 10.7 (5.8) days for decedents (*P* = 0.02). Patients qualified for CA had better CPC than patients disqualified (median [IQR]: 3 [1–5] for subjects qualified vs. 5 [3–5] for patients disqualified [*P* = 0.003]).

Comparative analysis (Table 3) revealed that patients with OHCA vs. IHCA were younger (mean [SD], 69 (14) years vs. 76 years [13]; *P* = 0.03), mostly male (67% vs. 51%; *P* = 0.04), more frequently had VF/pVT (72% vs. 28%; *P* <0.001), more frequently achieved ROSC (97% vs. 69%; *P* <0.001), had more defibrillation attempts (median [IQR], 1 [1–3] vs. 0 [0–1]), and had lower N-terminal pro-B-type natriuretic peptide (NT-proBNP) (median [IQR]: 1716.5 [512.5–4783.0] pg/ml vs. 5372.0 [1867.5–8137.8]; *P* = 0.002). Survival till hospital discharge was lower in patients with IHCA than with OHCA (36% vs. 54%; *P* = 0.03).

In the OHCA group, survivors had higher systolic blood pressure (SBP) (median [IQR]): 110 (100–125) mm Hg vs. 100 (80–110) mm Hg; *P* <0.001, as well as diastolic blood pressure (DBP; median [IQR]): 70 (60–75) mm Hg vs. 60 (50–67) mm Hg; *P* = 0.002 and SpO_2 (median [IQR]): 92 (90–94)% vs. 90 (85–92)%; *P* = 0.01 (Supplementary material, *Table S1*).

In the IHCA group, non-survivors were less likely to have shockable CA mechanism (VF/pVT[%]), 18 (62%) vs. 5 (10%); *P* <0.001, rarely achieved ROSC (%) 29 (100%) vs. 26 (51%); *P* <0.001. Defibrillation attempts were more frequent in the survivor group (median [IQR]): 1 [0–1] vs. 0 [0–0]; *P* <0.001), who also had higher SpO_2 (median [IQR]: 92 [90–95]% vs. 90 [85–90]%), more frequent PCI (19 [66%] vs. 19 [37%]; *P* = 0.028), and higher EF (median [IQR]): 43 (30–50)% vs. 29 (20–35)%; *P* <0.001 (Supplementary material, *Table S2*).

Patients referred to CA had significantly higher systolic blood pressure (median [IQR]; SBP: 109 [99–120] mm Hg vs. 95 [80–116] mm Hg; *P* = 0.02), higher sensitivity cardiac troponin T (hs-cTnT) (median [IQR]: 0.25 [0.05–0.25] ng/ml vs. 0.25 [0.10–1.48] ng/ml; *P* = 0.006) and MB isoenzyme of creatine kinase (CK-MB mass) (median [IQR]: 14.4 [4.7–60.5] ng/ml vs. 5.7 [2.8–15.1] ng/ml; *P* = 0.008) and lower NT-proBNP levels (median [IQR], 1862 [874–5651] pg/ml vs. 6446 [1792–8150] pg/ml; *P* = 0.03). They also had more frequently shockable rhythms (pVT/VF, 56% vs. 33%; *P* = 0.006), non-ST-segment elevation myocardial infarction (NSTEMI), 37% vs. 12%; *P* = 0.002 or with STE (STEMI), 39% vs. 4%; *P* <0.001 and lower CPC (median [IQR]: 3 [1–5] vs. 5 [3–5]; *P* = 0.003). Acute coronary syndromes (ACS) were diagnosed in 96 patients — more frequently in survivors (74% vs. 56%; *P* = 0.02), especially STEMI (36.4% vs. 20.7%; *P* = 0.04) and unstable angina (13.6% vs. 3.7%; *P* = 0.03).

For continuous variables, receiver operating curves analysis was performed to establish optimal cut-off values for endpoint prediction used further in the multivariable analysis — we identified left ventricular ejection fraction (LVEF) ≤30% with area under the curve (AUC) 0.734, *P* <0.001 and SpO_2 ≤90% with AUC 0.615; *P* = 0.01 (Supplementary material, *Table S3*).

Table 4. Independent predictors of death in the entire cohort identified in the multivariable logistic regression analysis

Variable	Odds ratio (95% CI)	*P*-value
Admission EF ≤30%	4.11 (1.69–10.03)	0.002
SpO_2 ≤90%	2.77 (1.19– 6.46)	0.02
NSTEMI	2.71 (1.03–7.21)	0.04
Early CA	0.28 (0.10–0.74)	0.01
Defibrillation	0.11 (0.05–0.27)	<0.001

Adjustment was made for the following variables: admission ejection fraction (EF); age; coronary artery disease history; systolic blood pressure; diastolic blood pressure; diabetes mellitus; sex; non-ST-segment elevation myocardial infarction (NSTEMI); percutaneous coronary intervention; any defibrillation attempt; pulseless ventricular tachycardia/ventricular fibrillation; peripheral oxygenation (SpO_2); coronary angiography (CA)

Abbreviations: see Table 1

In the multivariable logistic regression analysis, the following 5 independent predictors related to mortality were identified (Table 4). LVEF ≤30% on admission (OR, 4.11; 95% CI, 1.69–10.03), SpO_2 ≤90% on admission (OR, 2.77; 95% CI, 1.19–6.46), and initial NSTEMI diagnosis (OR, 2.71; 95% CI, 1.02–7.21) were related to higher mortality. The risk of death was lower in patients who underwent early CA (OR, 0.28; 95% CI, 0.10–0.74) or received at least one defibrillation (OR, 0.11; 95% CI, 0.05–0.27). No prognostic significance was identified for other analyzed factors including STEMI, unstable angina, PCI, CAD history, pVT/VF, pulseless electrical activity, systolic blood pressure, diastolic blood pressure, diabetes mellitus, hs-cTnT, age, sex, or serum creatinine level.

DISCUSSION

The main finding of our study is that cardiac arrest patients qualified for early CA differed considerably from those disqualified; however, in the multivariate analysis early invasive management strategy appears to be protective regarding short-term survival.

Our analysis was performed in a single tertiary cardiology center with access to the intensive care unit and overall survival was 45% — significantly higher than reported in most publications [9, 10]. Notably, our data seem consistent with reports from the Swedish Health Care Registry on Heart Disease (SWEDEHEART) [11]. Their reports gave information on angiographic findings and survival from all consecutive patients who had undergone CA due to sudden cardiac arrest (SCA) in western Sweden between 2005 and 2013. Mortality within the first 24 hours among all patients who underwent CA was 56 (9%) in the SCA group and 153 (1%) in the ACS group. After one week, 161 (26%) SCA patients and 412 (2%) ACS patients died. Total mortality at any time during the study period was 42% in the SCA and 14% in the ACS groups.

HACORE (HAnnover Cooling REgistry [12] presented the influence of obligatory therapeutic hypothermia and cardiac catheterization in the absence of a clear non-cardiac cause of arrest as part of the Hannover Cardiac Resuscitation Algorithm before intensive care admittance. Overall, 30-day mortality of all the subjects treated according to the prespecified algorithm and receiving hypothermia after OHCA was 41%; for those with ROSC before arrival at the hospital, it was 39%. Patients with ongoing CPR on hospital admission, necessitating either ongoing mechanical or extracorporeal CPR, had the highest in-hospital mortality rate of 58%.

Our study confirms that CAD may be the most common cause of OHCA. Acute coronary culprit lesions were observed in 87% of patients who qualified for early CA. Qualification to coronary angiography was followed by nearly 85% successful PCI procedures. These findings are similar to those reported by Garcia et al. [13] who assessed subjects resuscitated from shockable rhythms who got early admission to the cardiac catheterization laboratory. In this study, 197 (63%) patients survived until hospital discharge with positive neurological outcomes (CPC of 1 or 2), and 121 (52%) patients who underwent early CA also underwent percutaneous coronary intervention, whereas 15 (7%) were qualified for coronary artery bypass grafting.

In our multivariable logistic regression analysis, the risk of death was lower in patients who underwent early CA (OR, 0.28; 95% CI, 0.10–0.74). Coherent findings were described in a meta-analysis by Camuglia et al. [14] where overall survival in the acute angiography group was 58.8% vs. 30.9% in the control group (OR, 2.77; 95% CI, 2.06–3.72). Survival with good neurological results (as per the Utstein template) in the early angiography group was 58% vs. 35.8% in the control group (OR, 2.20; 95% CI, 1.46–3.32).

Receiving at least one defibrillation (OR, 0.11; 95% CI, 0.05–0.27) was an independent predictor of survival. Analysis by Moutacalli et al. [15] concerning benefits of immediate CA in survivors of out-of-hospital cardiac arrest without an obvious extracardiac cause confirmed that patients who received defibrillation (n = 127) had a mortality rate of 48%, compared to 88% in 33 patients with an initial non-shockable rhythm (primary asystole or pulseless electrical activity) (*P* <0.001). In the study by Zijlstra et al. [16], which investigated diverse defibrillation strategies in survivors after out-of-hospital cardiac arrest, 2289 (81%) survivors with a known defibrillation status were defibrillated, 1349 (59%) were defibrillated by emergency medical service (EMS), 454 (20%) were defibrillated by a first-responder AED, and 429 (19%) were defibrillated by an onsite AED. The percentage of survivors defibrillated by first-responder AEDs (from 13% in 2008 to 26% in 2013; *P* <0.001) and onsite AEDs (from 14% in 2008 to 30% in 2013; *P* <0.001) increased. The improved use of these non-EMS AEDs was correlated with the rise in the survival rate of subjects with a shockable initial rhythm.

In the POL-OHCA registry, which was a case-control study established on medical records, 3 400 000 emergency visits were recorded. Patients who were treated by EMS ambulance team using defibrillation and/or ordering at least 1 dose of 1 mg of epinephrine were regarded to have OHCA managed by CPR attempts. Defibrillation at OHCA site was identified as a positive marker of survival to hospital admission with OR 1.29 (95% CI, 1.18–1.41; P <0.001) [17].

We identified admission LVEF ≤30% as a strong independent predictor of death (OR, 4.11; 95% CI, 1.69–10.03), and that finding is consistent with observations made by Burstein et al. [18]. In their study, mean LVEF at 24 hours was 36.4% for survivors and 34.7% for non-survivors. LVEF <40% was not a significant predictor of survival in univariate analysis. In addition, it was not predictive either if the analysis was restricted to patients admitted to CCU or those qualified for cardiac catheterization.

In the Autonomic Tone and Reflexes After Myocardial Infarction (ATRAMI) study, which enrolled 1284 patients with recent MI, patients with LVEF of 35%–50% had a relative risk of 2.5 for cardiac mortality compared with patients with LVEF >50%, whereas in patients with LVEF <35%, the relative risk was 7.3 [19]. In an interesting analysis made by Narayanan et al. [20], LV diameter added to the risk stratification for sudden cardiac death (SCD) independently of LVEF. In multivariable analysis, severe LV dilatation was an independent predictor of SCD (OR, 2.5; 95% CI, 1.03–5.9; P = 0.04). In addition, subjects with both EF ≤35% and severe LV dilatation had higher odds for SCD compared with those with low EF only (OR, 3.8 [95% CI, 1.5–10.2] for both vs. 1.7 [95% CI, 1.2–2.5] for low EF only), implying that severe LV dilatation additively enhanced SCD risk.

We identified non-ST-segment elevation myocardial infarction as an independent predictor of death (OR, 2.71; 95% CI, 1.02–7.21). In the study by Lemkes et al. [21], which randomly assigned 552 patients who had cardiac arrest without signs of STEMI to undergo direct CA or CA that was postponed until after neurologic recovery, among patients who had been successfully resuscitated after out-of-hospital cardiac arrest and had no signs of STEMI, an approach of immediate angiography was not found to be better than a strategy of delayed angiography with respect to overall survival at 90 days. At 90 days, 176 of 273 patients (64.5%) in the immediate angiography group and 178 of 265 patients (67.2%) in the delayed angiography group were alive (OR, 0.89; 95% CI, 0.62–1.27; P = 0.51).

In the study by Behnes et al. [22], which sought to evaluate the predictive effect of acute myocardial infarction with STEMI and NSTEMI in patients with ventricular tachyarrhythmias and SCA on admission, multivariable Cox regression models exposed non-acute myocardial infarction (hazard ratio [HR] 1.46; P = 0.001) and NSTEMI (HR 1.46; P = 0.04) as connected with increasing long-term all-cause mortality at 2.5 years, which was also demonstrated after propensity-score matching.

In our multivariable logistic regression analysis, we identified the qualification for CA itself, as a negative predictor of death with OR 0.28 (95% CI, 0.10–0.74). Contrary to our study, in the previously described analysis made by Lemkes et al. [20], which was further analyzed after one-year follow-up [23], patients successfully resuscitated from out-of-hospital cardiac arrest and without signs of STEMI, an urgent angiography approach was not found to be superior to a strategy of postponed angiography regarding clinical consequences at 1 year. The Immediate Unselected Coronary Angiography Versus Delayed Triage in Survivors of Out-of-hospital Cardiac Arrest Without ST-segment Elevation (TOMAHAWK) trial by Desch et al. [24] evaluated 554 patients with positively resuscitated out-of-hospital cardiac arrest of possible coronary origin. The patients underwent either immediate CA (immediate-angiography group) or initial intensive care assessment with delayed or selective angiography (delayed-angiography group). At 30 days, 143 of 265 patients (54%) in the immediate-angiography group and 122 of 265 patients (46%) in the delayed-angiography group died (HR 1.28; 95% CI, 1.00–1.63; P = 0.06). The composite of death or severe neurologic deficit occurred more frequently in the immediate-angiography group (in 164 of 255 patients [64.3%]) than in the delayed-angiography group (in 138 of 248 patients [55.6%]), for relative risk (RR) of 1.16 (95% CI, 1.00–1.34). In the recently published EMERGE trial [25] which evaluated the 180-day survival rate with CPC 1 or 2 of patients who experienced an OHCA without STE on ECG and underwent emergency CA vs. delayed CA, there was no difference in the overall survival rate (emergency CA, 36.2% [51 of 141] vs. delayed CA, 33.3% [46 of 138]; HR 0.86; 95% CI, 0.64–1.15; P = 0.31) or in secondary outcomes between the 2 groups. Patients' populations in the above-cited studies were significantly different from ours and included only subjects without signs of STEMI.

Limitations

Our study has several limitations that should be taken into consideration while interpreting the results. The cohorts and interventions of the cited studies are different from the subjects and interventions of this study. This is a single-center study where all the patients were hospitalized in a tertiary cardiology department, which could shift the profile of subjects, especially the OHCA subset towards those with suspected myocardial infarction. Thus, the observed outcomes may not be fully recognizable although they reflect clinical practice in many multidisciplinary hospitals.

The absence of a clear impact of PCI upon survival is puzzling but may reflect, on the one hand, clarification of optimal management strategy even in the absence of acute coronary syndrome, and, on the other hand, difficulties in obtaining effective tissue reperfusion in cardiac arrest victims.

Our follow-up was limited to the in-hospital phase. Importantly, the study was not randomized so no comparisons regarding management strategies can be directly drawn although the result might be hypothesis-generating. A substantial number of patients were analyzed retrospectively based on medical records, which may have led to selection bias, even though no intervention factor existed in the prospectively cohort.

We must acknowledge the potential bias from mixed analysis of patients with OHCA and early IHCA.

CONCLUSIONS

In this single-center study of a tertiary cardiology department, those patients after cardiac arrest who were qualified for early CA had improved outcomes. In the multivariable logistic regression model, lower SpO_2, lower EF, and NSTEMI were independent risk factors of death, whereas early CA angiography and shockable rhythm improved survival.

Article information

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